Name (please print) _____   **Student Number**_____

Signature_____

Please check to indicate your section:

Check here:	**Section Number**	**Time of class**	**Instructor**
	01	MWF, 3:30 pm	Dr. R.S. Reid
	03	TTh, 8:30 am	Dr. J.W. Quail

CHEMISTRY 114.3 FINAL EXAMINATION

December, 2003

Time: 3 hours

READ THIS FIRST!

1. This is a **closed-book** examination. A data-sheet with a Periodic Table, values of numerical constants and other potentially useful information is attached to the back of this paper; you may detach this for convenience and keep it.

2. Simple scientific calculators are permitted. Alphanumerics, those with more than two lines of display and those capable of storing equations are **not** permitted. Electronic dictionaries are **not** permitted.

3. This paper has 16 pages, including the data sheet. Check that you have a complete copy.

4. Total marks are 160. Allowing for reading and checking, this is **one mark per minute.**

5. Answer multiple choice questions (Section A) **by circling a response on this paper**. All working should be done on this paper. No deductions will be made for incorrect answers; it is thus in your interests to attempt all questions. If you change your mind, indicate this clearly Multiple answers will be treated as no answer!

6. Answer other questions (Section B) on this paper. Show all working on this paper; **no other scratch paper or answer booklets are required or permitted.**

7. Before proceeding, **fill out the top of this paper (legibly!) and sign your name.**

alt

Question	**Mark**
B1 / 5	
B2 / 5	
B3 / 8	
B4 / 10	
B5 /6	
B6 /5	
B7 /12	
B8 /9	
Total Section B / 60	

Section A: Multiple Choice Questions.
These are worth 2 marks each. Answer as directed above.

1. The ground state electron configuration of antimony (Sb) is:
   A. $[Kr]4s^24f^{10}5p^3$ B. $[Kr]4d^{10}5s^25p^3$ C. $[Xe]5s^25d^{10}5p^3$
   D. $[Xe]5s^24d^{10}5p^3$ E. $[Kr]4s^24d^{10}4p^3$

2. Arrange the isoelectronic ions F^-, Mg^{2+}, N^{3-} in order of **increasing** ionic radius (smallest first and largest last).
   A. N^{3-}, F^-, Mg^{2+} B. F^-, Mg^{2+}, N^{3-} C. Mg^{2+}, N^{3-}, F^- D. F^-, N^{3-}, Mg^{2+} E. Mg^{2+}, F^-, N^{3-}

3. Which one of the following electronic configurations is impossible?
   A. $1s^2\,2s^2\,2p^5$
   B. $1s^2\,2s^2\,2p^6\,3p^1$
   C. $1s^2\,2s^2\,2p^6\,3s^2$
   D. $1s^2\,2s^2\,2p^6\,3s^2$
   E. $1s^2\,2s^2\,2p^6\,3s^3\,3p^6\,3d^8\,4s^2$

4. What is the wavelength of radiation that has a frequency of 2.10×10^{14} s^{-1}?
   A. 6.30×10^{22} m   B. 7.00×10^2 nm   C. 7.00×10^5 m
   D. 1.43×10^{-6} m   E. 3.00×10^8 m

5. Complete this sentence: Atoms emit visible and ultraviolet light
   A. as they are heated and the solid melts to form a liquid.
   B. as the atoms condense from a gas to a liquid.
   C. as electrons jump from lower energy levels to higher levels.
   D. as electrons jump from higher energy levels to lower levels.
   E. as the electrons move about the atom within an orbital.

6. Which one of the following atoms should have the smallest first ionization energy?
   A. Be   B. Na   C. Rb   D. K   E. Li

7 Which of these species: ^{35}Cl, ^{40}Ca, ^{14}C and ^{34}S, has an equal number of protons and neutrons?

A. ^{35}Cl B. ^{41}Ca C. ^{12}C D. ^{34}S E. none of the above.

8 Arrange the following atoms (B,C,N) in order of decreasing (largest to smallest) atomic (covalent) radius:

A. B, N, C   B. C, B, N   C. B, C, N   D. N, C, B   E. None of A, B or C

9. How many of these substances are subject to dispersion intermolecular forces in the liquid form: water, ethanol, methane, ammonia?

A. 0   B. 1   C. 2   D. 3   E. 4

10. The first ionization energy of an atom X is the energy change associated with which of the following processes?

A. $X^-(g) + e^- => X^{2-}(g)$

B. $X^+(g) => X^{2+}(g) + e^-$

C. $X(g) => X^+(g) + e^-$

D. $X(g) + e^- => X^-(g)$

E. $X^+(g) + e^- => X(g)$

11. In the van der Waals equation of state for gases, the symbol a corrects for non-ideal behaviour related to:

$$\left(P + \left[\frac{n^2 a}{V^2}\right]\right)(V - nb) = nRT$$

A. the dipole moment of the gas molecule
B. the intrinsic volume of one mole of molecules of the gas
C. the attractive forces between the gas molecules
D. that portion of the total volume which is not occupied by the gas molecules
E. Boyle's law

12. Deviations from the Ideal Gas Law for real gases are greater at
A. low temperatures and low pressures.
B. low temperatures and high pressures.
C. high temperatures and high pressures.
D. high temperatures and low pressures.
E. cannot answer without knowing the identity of the gas.

13. A 34.0-L cylinder contains 305 g $O_2(g)$ at 22 ^oC. What mass of $O_2(g)$ must be released to reduce the pressure in the cylinder to 1.15 atm if the temperature remains constant?
A. 305 g   B. 253 g   C. 201 g   D. 161 g   E. 51.6 g

14. What is the core charge on an oxygen atom?
A. +8   B. +6   C. +4   D. +2   E. 0

15. Which of the following elements would have chemical properties most similar to those of fluorine?
A. Sodium   B. Lithium   C. Chlorine   D. Uranium   E. Germanium

16. A magnesium ion, Mg^{2+}, has:
A. 12 protons and 13 electrons   B.   24 protons and 26 electrons   C. 24 protons and 22 electrons
D. 12 protons and 10 electrons   E.   12 protons and 14 electrons

17. If a gas at standard temperature and pressure occupies a volume of 50.0 L, what is its volume when the temperature is -40 ^oC and the pressure is 0.900 atm?
A. 47.4 L   B. 22.4 L   C. 7.62 L   D. 0.0211 L   E. cannot be calculated

18. Which of the following formulas would be predicted for a compound between gallium and fluorine?
A. Ga_2F B. Ga_2F_3 C. GaF_2 D. Ga_3F_2 E. none of these

19. What are the percentages by mass of Na and of C, respectively, in $Na_2CO_3 \cdot 10\ H_2O$?

A. 16.1, 4.2
B. 43.4, 11.3
C. 37.1, 9.7
D. 8.7, 4.6
E. none of the above

20. Which of the following processes is expected to be endothermic?

A. freezing of Hg(liq) at its normal melting point (-38.4 ^oC)
B. combustion of diamond [C(dia)] to form CO_2
C. the cooling of 1.0 kg of water from 10.0 ^oC to 5.0 ^oC
D. all of these
E. none of these

21. Equal volumes of nitrogen and oxygen gas, under the same conditions of temperature and pressure (assuming ideal behavior):

A. have the same number of electrons
B. have the same number of molecules
C. have the same average molecular velocity
D. have the same mass
E. have the same density

22. An endothermic reaction causes the surroundings to

A. warm up.   B. become acidic.   C.   condense.
D. decrease in temperature.   E. release CO_2.

21. In order to convert an empirical formula to a molecular formula, what information is required?

A. the density of the substance (if it is a solid and the crystal structure is known).
B. the relative numbers of each kind of atom present in the substance
C. the molar mass of the compound.
D. any one of A, B or C
E. none of A, B or C

24. What is the partial pressure of nitrogen gas in a mixture containing 0.50 mol of nitrogen molecules and 1.0 mol of hydrogen molecules, if the total pressure is 0.60 atm?
A. 0.60 atm   B. 0.40 atm   C. 0.36 atm   D. 0.20 atm   E. 0.18 atm

25. What is the pH of a 0.0048 **M** solution of KOH?
A. 2.3   B. 7.0   C. 9.3   D. 10.9   E. 11.7

26. If a solution containing 4.000 g of NaOH is exactly neutralized by 80.00 mL of an aqueous HCl solution, the molarity of the HCl solution must have been...
A. 0.001250 **M**   B. 0.001370 **M**   C. 1.250 **M**   D. 1.370 **M**   E. none of these

27. A strong electrolyte:
A. has low solubility in water
B. is incompletely ionized in aqueous solution at moderate concentrations
C. is completely ionized in aqueous solution at moderate concentrations
D. always ionizes to give a neutral solution
E. always ionizes to give either an acidic or a basic solution

28. In a 0.10 **M** aqueous solution of sodium fluoride (a weak base):
A. $[H_3O^+] = 0.10$ **M**   B. $[OH^-] = 0.10$ **M**   C. $[OH^-] > 0.10$ **M**
D. $7 < pH < 13$ E. $1 < pH < 7$

29. The respective oxidation numbers of the two nitrogen atoms in ammonium nitrate, $[NH_4]^+[NO_3]^-$, are:

A. +5 and +5
B. +3 and +5
C. -3 and +3
D. -3 and +5
E. none of these

30. Which of the following represents a conjugate acid-base pair by the Bronsted-Lowry definition?

A. H_3PO_4 and HPO_4^{2-}
B. H_2SO_4 and SO_4^{2-}
C. HPO_4^- and PO_4^{3-}
D. all of these
E. none of these

31. Which of the following is a strong acid in water?
A. HF
B. HClO
C. $HClO_2$
D. $HClO_3$
E. $HClO_4$

32. Which of the following substances does **not** yield an acidic solution when dissolved in water?
A. HOBr
B. $Ba(OH)_2$
C. CO_2
D. HCl
E. SO_2

33. Atom A has 2 electrons in its valence shell and atom B has 6 electrons in its valence shell. The formula expected for an ionic compound of A and B is:
A. A_3B
B. AB
C. AB_3
D. A_2B_6
E. A_6B_2

34. Which of the following compounds exhibits ionic bonding?
A. C_2H_6
B. Na_2S
C. H_2S
D. $SiBr_4$
E. PCl_3

35. Which of the following elements cannot have more than eight electrons in the valence shell?
A. Br
B. Ca
C. Si
D. N
E. S

36. Which of the following molecules would **not** be expected to have a dipole moment?
1. $CHCl_3$ 2. CO_2 3. CCl_4 4. HCl
A. 1, 2, 3, and 4
B. 1, 2, and 3
C. 2, 3, and 4
D. 1 and 2
E. 2 and 3

37. On the basis of electronegativity, which pair of elements would form the **most polar covalent bond**?
A. C, F   B. N, F   C.   C, N   D. C, O   E. N, O

38. Which of the following molecules has an unpaired electron in its ground state?
A. N_2O_5 B. Cl_2O C. NF_3 D. ClO_2 E. ClF_5

39. For a liquid in equilibrium with its vapor a straight line is obtained by plotting:
A. P vs T   B. log P vs T   C. log P vs 1/T   D. 1/P vs log T   E. none of the above.

40. What intermolecular force is **most** important between water atoms in dilute NaCl(aq) solutions?
A. Ion-ion   B. Ion-dipole   C. Dipole-dipole D. London   E. Hydrogen bonding

41. Compressibility and low density are properties usually associated with
A. gases.   B.   liquids.   C.   solids.   D. all of these.   E. none of these.

42. In which of the following substances should hydrogen bonding contribute significantly to the attractive interactions among the molecules?
A. H_2O(liq)   B. HF(liq)   C. NH_3(liq)   D. all of these   E. none of these

43. The tendency of liquids to assume a spherical shape in free fall is the result of
A. density   B. fluidity   C. surface tension D. viscosity   E. none of these

44. Given the following boiling points: carbon disulfide, 46.5 °C; carbon tetrachloride, 76.7 °C; acetone, 56.5 °C, the least volatile of these three liquids is:

A. CS_2 B. CCl_4 C. acetone

D. All are equally volatile.   E. None of these is volatile.

45. Equal amounts (20 g) of water are sealed in each of two flasks, one 250 mL, the other 1000 mL in volume. Both are held at 29°C until the liquid-vapor equilibrium is established. In both cases, some liquid remains. If the measured vapor pressures of the water in the 250-mL flask is 30 mmHg, the vapor pressure in the 1000-mL flask will be:

A. 7.5 mmHg   B. 15 mmHg   C. 30 mmHg   D. 120 mmHg

E. This cannot be determined from the information given.

46. Which of the following aqueous solutions has the least $[H^+]$ at 25°C?

A. 0.020 **M** NH_3 B. 0.020 **M** $HClO_2$ C. 0.020 **M** HCl

D. 0.020 **M** NaOH.   E. all have the same $[H^+]$

47. Sodium fluoride , NaF(s) and magnesium oxide, MgO(s) both have the rock salt (NaCl) structure with very similar unit cell edge length. If the lattice energy of NaF is -900 kJ mol^{-1}, which of the following best approximates the lattice energy of MgO(s), in kJ mol^{-1}?

A. -225   B. -450   C. -900   D. -1800   E. -3600

48. In diamond, each carbon is covalently bonded to _____ other carbon atoms.

A. 2   B. 3   C. 4   D. 6   E. 8

49. Which statement is **NOT** correct for an hexagonal close packed arrangement of identical spherical atoms?
A. Each atom has a coordination number of 12.
B. The packing efficiency is the same as for cubic close packing.
C. Each atom is surrounded by identical atoms in an octahedral arrangement.
D. The sequence of close-packed layers is abababa.....
E. The atoms are packed to leave the minimum of empty space between them.

50. A substance is subjected to x-ray diffraction. The resulting diffraction pattern contains many sharply defined spots. The substance is:
A. gaseous   B. crystalline   C. amorphous   D. plastic   E. liquid

Section B: Other Questions.
Answer in this booklet.

Question B1 (5 Marks). What volume of 0.0422 **M** $Ba(OH)_2$ is required to neutralize 10.00 mL of 0.1526 **M** $HNO_3(aq)$?

Question B2 (5 marks). Fill in the blanks in the following table. If a compound has no molecular formula, write "NA" (not applicable).

Name	Empirical Formula	Molecular Formula
Hydrogen Peroxide	HO	H_2O_2
		P_4
Potassium Hydrogensulfate		
	$Mg(ClO_3)_2$	
Methane		
Glucose		$C_6H_{12}O_6$
	Ag_2CO_3	NA

Question B3 (8 marks). 10.00 g of steam at 100.0°C are passed into 250.0 g water at 25.0 °C. What is the final temperature of the water?

(ΔH^o_{vap} = 40.6 kJ mol^{-1} at 100.0 °C for water; Specific heat of $H_2O(l)$ = 4.18 J g^{-1} °C^{-1})

Question B4 (10 marks). 65.0 g of calcium carbonate, $CaCO_3$, is heated, and decomposes completely to calcium oxide, CaO, and carbon dioxide.

(a) What mass of calcium oxide is produced?

(b) what volume of carbon dioxide is produced, at 22.0 $^\circ$C and 1.00 atm pressure?

The calcium oxide is now reacted with 15.0 g water, to produce calcium hydroxide, $Ca(OH)_2$. You may assume this reaction goes as completely as possible.
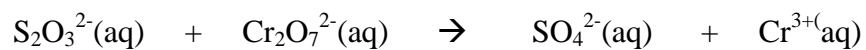
(c) What mass of calcium hydroxide is produced?

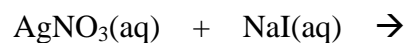(d) What mass of water is left at the end of this second reaction?

(e) What mass of calcium oxide is left at the end of this second reaction?

Question B5 (6 Marks).

(a)   Balance the following equation, taking place in *acidic* solution.

$S_2O_3^{2-}$(aq)   + $Cr_2O_7^{2-}$(aq)   → SO_4^{2-}(aq)   + Cr^{3+}(aq)

(b)   Complete and balance the following equation. Indicate any solid products.

$AgNO_3$(aq)   + NaI(aq) →

(c)   Balance the following equation, taking place in *basic* solution.

As_2S_3(aq)   + H_2O_2 → AsO_4^{3-}(s)   + SO_4^{2-}(aq)

Question B6 (5 marks). Polonium (Po) is the only element to crystallize in the simple (primitive) cubic crystal system (unit cell shown at right). The distance between nearest neighbor Po atoms in the structure is 335 pm. What is the density of Po metal?
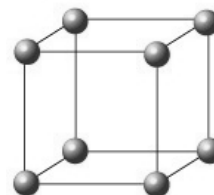
Question B7 (12 marks). Fill in the blanks in this table. A sample row has been filled in for you. The central atom is underlined in each case. If the Lewis structure involves resonance, draw only one resonance form, but write "resonance" next to it.
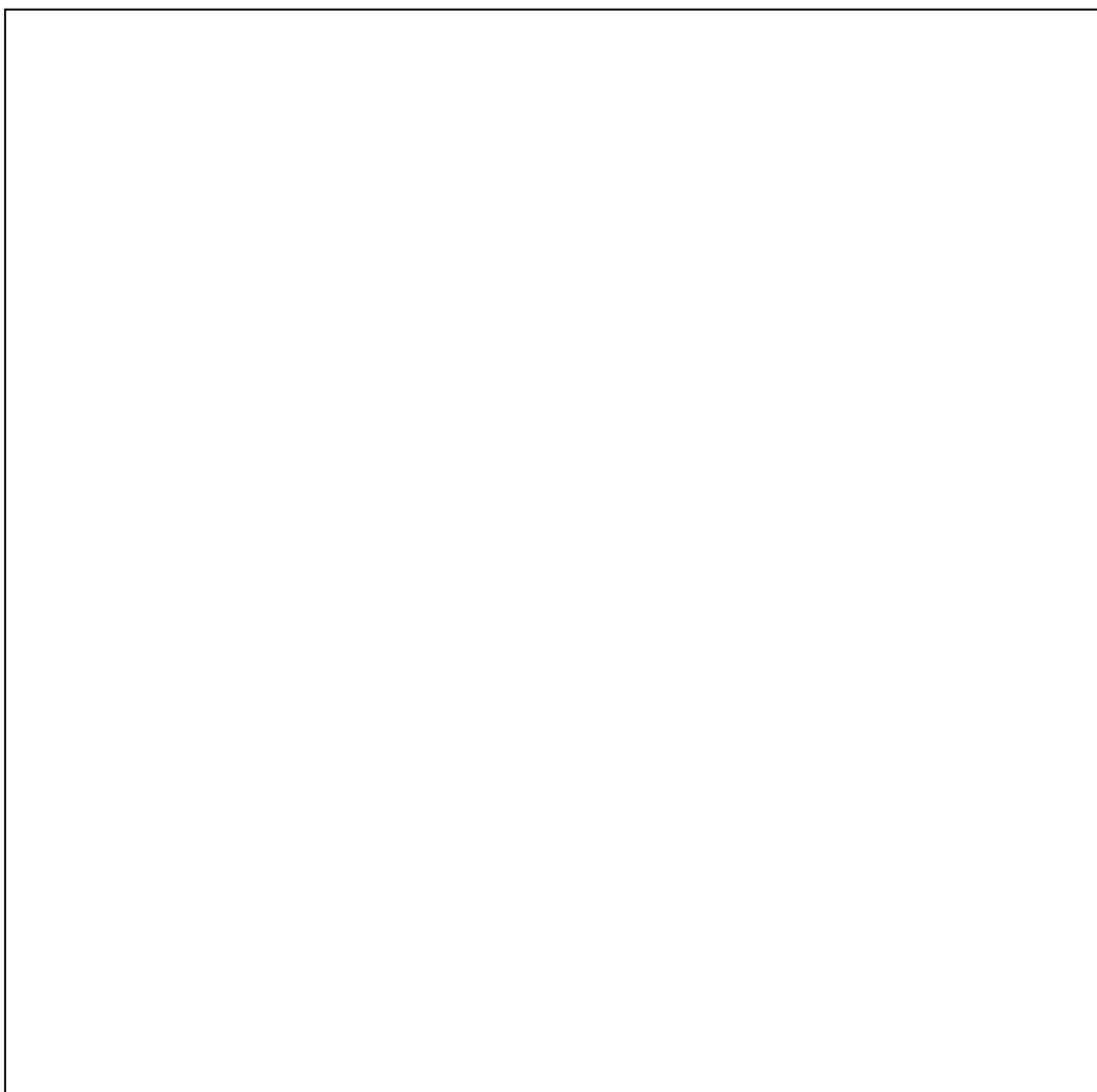
Molecule or Ion	Lewis dot structure	Electron Group Geometry *	Description of Molecular Geometry (Shape)**
$H_2\underline{O}$	H—Ö—H	tetrahedral	bent (109°)
$\underline{Xe}F_2$			
$\underline{P}F_4^+$			
$\underline{C}O_3^{2-}$			
the chlorate ion			

* You may give a verbal description OR a drawing. In the case of a drawing, it must be unambiguous, with important bond angles indicated.

Describe the arrangement of **ATOMS around the central (underlined) atom.

Question B8 (9 Marks). In the box below, draw a phase diagram for carbon dioxide. On your diagram, label the following:

(a) the axes.
(b) the stable phases in all areas of the diagram.
(c) the location of the normal melting and boiling points, the triple point and the critical point.

(d) With reference to your diagram, explain why you would predict that solid CO2 ("dry ice") does not melt but sublimes at 1 atm ambient pressure.

~ The End ~

1 A																	8 A
1 **H** 1.008	2 A											3 A	4 A	5 A	6 A	7 A	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012				THE PERIODIC TABLE of ELEMENTS							5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.990	12 **Mg** 24.305	3 B	4 B	5 B	6 B	7 B	8 B 8	9	10	1 B	2 B	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.30
55 **Cs** 132.9	56 **Ba** 137.3	57 **La *** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (210)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac **** (227)	104 **Rf** (257)	105 **Ha** (260)	106 **Sg** (263)	107 **Ns** (262)	108 **Hs** (265)	109 **Mt** (266)									

*	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (147)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
**	90 **Th** 232.0	91 **Pa** (231)	92 **U** 238.0	93 **Np** (237)	94 **Pu** (242)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (249)	99 **Es** (254)	100 **Fm** (253)	101 **Md** (256)	102 **No** (254)	103 **Lr** (257)

Useful Data

Avogadro's Number: $6.0221 \times 10^{23} \text{ mol}^{-1}$

Gas Constant: $0.082058 \text{ L atm K}^{-1} \text{ mol}^{-1}$
$8.314 \text{ J K}^{-1} \text{ mol}^{-1}$

Planck's Constant: $6.6261 \times 10^{-34} \text{ J s}$

1 atomic mass unit (amu) $1.6605 \times 10^{-27} \text{ kg}$

Charge on the electron $1.6022 \times 10^{-19} \text{ Coulomb}$

Speed of light in a vacuum $2.998 \times 10^{8} \text{ m s}^{-1}$

The roots of a quadratic equation: $x = \dfrac{-b \pm \sqrt{(b^2 - 4ac)}}{2a}$

Standard Temperature and Pressure: Pressure = 1 atm = 760 Torr = 760 mm Hg = 101.325 kPa

Temperature = 0°C = 273.2 K